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# How do fault zones develop?: Findings from the observation of natural fault rocks

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While earthquakes occur by fracturing of rocks, it has been known that they occur along the existing faults, not everywhere in the crust. Accordingly, the development of fault structures is an important topic to analyze seismic activities. However, not much has been known about this problem. For example, since faults consisting of fracture zones are weak planes, some geologists believe that the width of fracture zones does not increase because of concentrated displacement only along fracture zones. On the other hand, it has been known that the width of fracture zones increases with increasing displacement. Schrank et al. (2008) have shown that fracture zones are initiated as discrete fault plane, which subsequently becomes anastomosing fracture zones, and finally the undeformed parts surrounded by fracture zones become fracture zones, thereby increasing the volume of them. Takeshita and El-Fakharani (2013) have shown a similar development of fracture zones for hand-specimen scale shear zones in the Sambagawa quartz schist deformed at the conditions of frictional-viscous transition. According to this study, the formation of micro-fracture zones is accommodated by dynamic recrystallization of quartz, and accompanied by the precipitation of very-fine-grained muscovite from the solution which percolates along micro-shear zones, thereby leading to the formation of polycrystals consisting of very-fine-grained quartz and muscovite along the micro-fault. As time passes, the micro-shear zones become anastomosed, and the width and grain sizes of constituting quartz and muscovite increase. Since the fracture zones consist of very-fine-grained minerals, they are perhaps deformed by dissolution-precipitation creep at low stress. Stress concentration is inferred to occur in the undeformed lenses surrounded by micro-shear zones, where new micro-shear zones are developed. The same processes are repeated with time, thereby leading to the increased volume of fracture zones (i.e. growth of fracture zones). Although this study has been conducted on fracture zones at hand-specimen scale, the fracture zones at outcrop and map scales are perhaps developed by similar processes. There are two key processes for the development of fracture zones. One is its anastomosing development, which is in accord with the geometries of fracture zones at outcrop and thin-section scales observed by geologists. At map scales, these correspond with the segment and jog structures, which have been well known structures inherent to natural faults. We will report an example of small-scale fault jog structures, which has been recently found along the Median Tectonic Line, Mie Prefecture, southwest Japan (Arai and Takeshita, 2015, JpGU). The other key process is the percolation of fluid along fracture zones, and resultant alteration reaction of minerals and enhancement of dissolution-precipitation creep via fluids. Relating to this topic, we will report mass transfer via fluids in fracture (cataclasite) zones of the Median Tectonic Line, which leads to the weakening of fault zones (Kaneko et al., 2015, JpGU).

Keywords: growth of fault zone, shear or fracture zone, dissolution-precipitation creep, anastomosing fault zone, frictional-viscous transition, mass transfer via fluids